

Title: The Personalized Medicine of sex differences

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Abstract

Personalized Medicine (PM) is a new paradigm where physicians use all the available information (clinical history, molecular profile, DNA, imaging etc.) of each patient to tailor the treatment to his/her unique individual characteristics. One of the most evident physiological features of a person is its biological sex [1]. However, this information is rarely used in clinical research and we know little about the role that plays in determining many clinically-relevant features such as disease predisposition or sensitivity to different treatments.

For instance, in 2009, only 20% of biomedical experiments employing animals published in journals such Nature, Science or PLoS Biology, considered both sexes [2]. The 20% and the 10% of the publications did only studied males or females separately [2]. The remaining 50% did not even reported the sex of the animals which unexplicitly indicates that sexual dimorphism might be deemed as irrelevant [2]. When the research focuses on cell cultures, something similar happens: only 30% of articles reported the sex of the cells [3]. The panorama changes when the subject of study are humans: more than 60% of the scientific experiments contemplated both sexes meanwhile the remaining 40% take mostly men as reference [2].

One of the main reason for these inequalities seems to be an economic issue. For example, female *Wistar* rats are 4 times more expensive compared to male ones [4]. This situation is not only relegated to animals but also humans. In Biomedical Research, women are considered a confounding variable as well as more expensive due to their fluctuating hormone levels [5]. Besides, pregnant women or of childbearing potential are usually excluded [5]. Despite these facts, a direct correlation exists between the number of GSA (Gender and Sex Analyses) and the number of female authors involved in such publications. Evidence shows that independently of women being the first or last author or more numerous among the group of authors, they are more likely to perform GSA [6].

In general, the omission of GSA in Biomedical Research has regrettable repercussions. A good exemplification of this is the case of the withdrawal of 10 drugs from the market in the late 90s in USA. Of those, 7 provoked side effects on female population [4]. On the other hand, although one third of hip fractures caused by osteoporosis happens in elder men, the focus group when studying it points to women as its appearance has been largely linked to menopause [4].

Diverse organizations such the European Commission or the National Institutes of Health (NIH) in USA among others, have acknowledged the importance of this matter by establishing new policies and goals within their scope of Biomedical research [5,7,8,9].

Although measures to increase GSA are being implemented, we are still far from understanding the role of biological sex in PM. A critical step that will bring us closer to this goal will be the inclusion of "biological sex" as a key variable in all future biomedical research. That way, we will be able to tailor clinical treatments to benefit both sexes.

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